Appendix 1

Methodology and Procedures to be used for Estimating CO_2 Removals as the Result of Remaining C in End Product Sinks.

Background Terminology

CARBON SEQUESTRATION. The uptake and storage of Carbon. The removal of carbon from the atmosphere. Trees and plants absorb atmospheric CO_2 . Carbon is stored in carbon sinks or pools (i.e. forests).

CARBON SINKS OR POOLS. Reservoirs of Carbon.

CARBON FLUX. Rate of exchange of carbon between pools (i.e. forest to harvested wood, to products in use, to landfills).

REMOVALS. The term reflects the removal, by sequestration, of CO_2 from the atmosphere. In the “balance sheet” of anthropogenic GHG emissions, removals are the credits that counter the emissions (the debit).

Carbon Sinks and Fluxes Stressing the Wood Product System

Oceans

Geological formations

Grasslands

- mfg. residues

Forests → Harvested wood → ***products in use*** → landfill biofuels

- decaying wood/inc.

Concept and Justification

As explained in the text of the Protocol, accounting for product carbon sink removals is simply the correction or adjustment to the accounting practice that "books" all harvested biomass volumes (or weights) as emissions for the year in question. The Intergovernmental Panel on Climate Change (IPCC) provides several options for estimating carbon stock changes or fluxes from Land Use Changes and Forestry (LUCF). These options are:

- using annual land change statistics on LUCF to derive total carbon flux values, or
- using carbon stock estimates derived from periodic surveys of natural forests. The U.S. uses option two for its estimates.

In addition, IPCC also provides two options for accounting of the harvested wood.

> **Option 1.** All harvested wood replaces products that decay in the year of the inventory because the amount of carbon in harvested wood would equal the amount of carbon emissions from the production in the inventory year.
>
> **Option 2.** Accounting is based on a variable rate of decay for harvested wood products according to its disposition, e.g. product pool, landfill, etc. Again, the United States uses option two, which is the variable rate of decay, according to methods from Skog and Nicholson (1996) and Heath (1996).

GENERAL. According to Article Five of the Framework Convention on Climate Change (UNFCCC), signatories are obliged to submit annual GHG inventories for the country as a whole. The Environmental Protection Agency (EPA) submits the information for the U.S. Since 1996, the United States' report on GHG inventories has included the annual removals from both forest carbon sink and product carbon sink, including landfills.

In the UNFCCC, "sink" is defined as, "any process, activity or mechanism that removes a GHG." This definition fits squarely in the results of the manufacturing process that yields biogenic products, such as those produced by Georgia-Pacific.

The GHG inventories report the amount of sinks and the analysis of both forest carbon sink and product sink trends. They indicate the increasing importance of the product carbon sink component of the "removals". As forest carbon sinks decrease for varied reasons (e.g. increasing areas set aside and not included), the product carbon pool increases As part of general population increases and quality of life.

THE US NATIONAL GHG INVENTORY METHODOLOGY AS THE BASIS FOR OUR METHOD. Conceptually, the methodology used to calculate the US national GHG emissions net is applicable to corporations for both carbon stock changes and product carbon sinks removals estimations. In the estimation, two major elements are important: 1) the annual product production data; and 2) the calculation methodology.

As indicated on the following page, the US GHG Inventory is able to track down the forest carbon fluxes all the way to the estimation of the carbon sinks from the harvested product in use.

The Method of Calculation in the US GHG Inventory is our Basis. For example, the US 1990-2000 GHG Inventory report, for 2000, GHG emissions as

Gross Emissions	7,001.2 Teragrams CO_{2eq}
Net Emissions	6,098.7 Teragrams CO_{2eq}
Sinks	902.5 Teragrams CO_{2eq}

How Are Sinks Distributed? The 902.5 Tg CO_{2eq} emission is broken down as:

Forest carbon Flux	**770.0**
Agricultural Soils	67.4
Urban Trees	58.7
Landfilled yard trimmings	6.4

Our interest is on the ***Forest Carbon Fluxes - 770***

Disaggregating the Forest C Flux -770 Tg

A) Forest Carbon Stock (546.3) Tg CO_{2eq}

Trees	447.3
Understory	14.7
Forest floor	29.3 (an emission)
Down Dead wood	58.7
Forest soils	55

B) Harvested Wood C Stocks (223.7)

Wood products	66
Landfilled wood	157.7

(data for 2000, from US GHG Inventory)

The above "tracking" of the C fluxes in the US GHG Inventory report is evidence that it is feasible to quantify the C exchanges between pools down to the carbon in the products in use.

Methodology in National Accounting of C Stock Changes in Wood Products

Carbon is tracked from forests through products and end uses, to landfills and emission by decay and burning.

- From Forest to harvested roundwood
- From roundwood to primary products and residues
- From primary products to end-use products and disposal

Use of equation from Row & Phelps to estimate fraction of C remaining in end use for each year after after mfg. It predicts half-life for carbon in each end use. Half life is is the time after which half the carbon place in use is not longer in use.

After retirement from wood-in use sinks, bioproducts are recycled, landfilled, burned w & w/o energy, or let decay

The Method of Skog & Nicholson (Forest Product Journal, July/August 1998, p. 75-83)

The Method of Calculation in the US GHG Inventory

The carbon stock calculations in the company's forest management operations are explained elsewhere and generally follow the results of merchantable wood accounting with additional extrapolations to total biomass. In most cases, carbon soil changes are considered minimal in conventional forest management practices. If changes in land use are involved, specific considerations may be needed.

Some specific considerations for product carbon sink removals calculations include:

> Considering only end-use products. Primary production cannot be included since the transformation from raw material to finished products occurs rapidly. For example, in the case of containerboard that is used to make corrugated packaging, only corrugated packaging production should be included.
> Estimations for forest products deposited in landfills. These are not justifiable to the company and are not part of the inventory estimations for category or Scope Level 4. When the discarded product arrives at the landfill, the chain of property has been broken more than once. Proper accounting and justification as an owned "removal" for the company would be elusive at the very least. Therefore, the landfill carbon pool is properly included in the national GHG inventory.

Characterization Model for Estimating Remaining Carbon in Product Sinks.[1] To estimate the amount of carbon equivalent that can be considered remaining in storage in product sinks, the retirement rate of the forest products and carbon should be estimated according to the functionality of the product. Row and Phelps (USDA) have developed a characterization model that uses a logistics curve to estimate the proportion (%) of wood products remaining in the end-use sink. It is based on the half-life average and the functional use of the specific product. The Internal Revenue Service (IRS) of the U.S Department of Treasury generates half-life estimates for a variety of products according to functional categories such as single-family building, multi-family building, etc. Logically, different kinds of wood products can be classified into one given functional category. This model is reflected in the U.S. Annual Inventory of GHG, an official report to the United Nations Climate Change Framework Convention.

The time a wood product remains in use (T) is determined largely as a function of the average useful life (L) and the proportion (P) of that product remaining in the sink at a selected time. The selected T of 100 years exceeds the higher half-life average value of 67 years. The selection also reflects the 100-year horizon selected for the GWP factors. In this manner, the indicator results from the two impact categories will be expressed as C-equivalent and in the same time horizon. T and P are expressed as:

$$T = f(L,P) \qquad P = 0.5 / [1+2(\ln T - \ln L)]$$

REFINING THE CHARACTERIZATION MODEL AND FACTORS FOR THE PRODUCT SINKS. The USDA Forest Service developed an equation to account for recycling that extends the useful half-life of the C stored in a particular product end-use sink and increases the remaining fraction.

[1]Excerpted from ISO 14047-TR-2002.

The equation below illustrates the extended half-life, where **L**= Revised expected half-life, **H** =the original half-life and **R**= the proportion the product is being recycled into the same product category.

$$L= H/ (1-R)$$

The benefits of recycling/reuse in estimating product carbon sink removes can be represented in other ways. Galeano[2] describes different procedures of forest product allocation based on the "number of uses", a concept transferred into the ISO 14041 standard for allocation practices.

[2]Galeano, S.F. Ch. 35, "Life Cycle Assessment of Product Systems" in " Industrial Environmental Control", 3rd Edition, edited by A.M. Springer (2000).

Steps in the G-P Calculating Method for Annual Carbon Removal from the Forest Product Sink

1- Identify end products of the company (not primary products readily converted into end prod.)

2- Express production in terms of tons (for both paper and wood products)

3- Convert tons of end products to tons Carbon

4- Allocate quantities of C in end products into functional categories

5- Apply fractions of C remaining after 100 yrs, to above (Row & Phelps)

STEP 1

Identify end products of the company (not primary products).

Examples:

Industrial Wood Products: MDF, particle board, hardboard,

Structural Panels; I-beams, OSB, Plywood

Lumber

Gypsum paperboard

Corrugated packaging

Tissue & Towel

Printing paper; communications, copier, etc.

No market pulp/containerboard/ parent rolls production included

STEP 2

Express production in terms of tons (for both paper and wood products).

Examples

Hardboard	850,000	MSF x factor =	260,000 tons
Lumber	2,500,000	MBF x factor =	3,300,000 tons
Packaging	2,900, 000	tons x factor =	2,900,000 tons

There are available conversion factors for all different wood products from MSF, MBF, MLF, etc. to tons

STEP 3

Convert tons production to tons Carbon

Examples

Lumber	Wood, 50%	C content, 44%
Printing paper	80%	44%
Packaging	90%	44%

STEP 4

Allocate quantities of C in end products into functional categories.

Examples

Categories	*% in Category*	*MM tons C*
WOOD PRODUCTS		
1 family residence	40	0.66
multi-family residence	30	0.49
Upkeep/improvement	20	0.33
non-residential	10	0.16

STEP 5

Apply fractions of C remaining after 100 years, to above (Row & Phelps) and obtain removals sought. Original work (1990) comprised 12 functional categories. Used a logistics curve function to represent the retirement of each product category according to its half-life. From it, R&P developed remaining fractions after certain No. of years, up to 100, for each functional category[1].

Examples

Category & Product	MM tons C	Fraction Remaining	Removal MMtons C
Lumber in I fam. Residence	0.60	0.34	0.204
Printing Paper	1.80	0.05	0.09

([1]See also, table and graph next slides at end of this Appendix)

As indicated in Step 5, the amount of annual C removal from the product carbon sink to be reported as a category in the G-P GHG Inventory is given in the right-hand side column.

Note: Reflecting Recycling Benefits

Row & Phelps suggested extending the original half-life (HL) of the product by incorporating the recycle rate (RR) for a given product.

$$\textbf{HL ext.} = \textbf{HL orig.} / (1 - \textbf{R.R.})$$

There are other ways such as number of uses, etc. that can be used to reflect this ONE aspect of recycling.

ANOTHER aspect of the recycling benefits would be to estimate the increase C sequestration (increase in forest C sink) by extending the carbon storage benefit of the equivalent growth of the tree not harvested because of recycling.

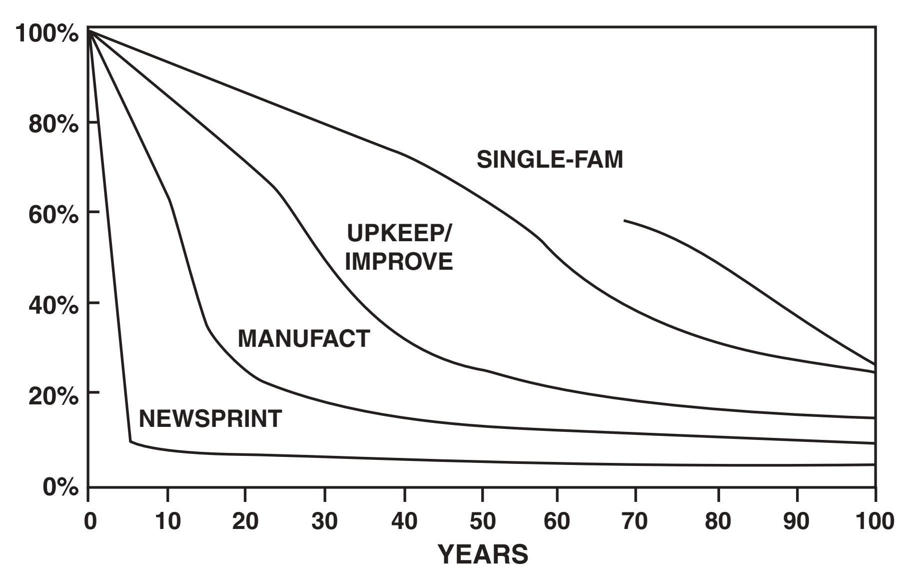
Carbon Release From Wood-in-use Sinks Over Time

Metric tons of carbon

Period ending in year	1-family	Housing Multi-	Mobil	Maint. & Repair	Non-res building	Manu-f'trs	Ship-ping	Other uses	News-print	Print/write	Tissue papers	Pack-aging
5	0.095	0.021	0.043	0.123	0.027	0.133	0.109	0.142	0.766	1.024	0.711	0.698
10	0.095	0.021	0.044	0.123	0.027	0.135	0.141	0.142	0.033	1.244	0.024	0.027
15	0.095	0.021	0.076	0.123	0.027	0.235	0.030	0.142	0.012	0.249	0.009	0.010
20	0.095	0.021	0.036	0.115	0.027	0.112	0.012	0.133	0.007	0.101	0.005	0.006
25	0.095	0.021	0.015	0.136	0.027	0.047	0.007	0.157	0.004	0.057	0.003	0.004
30	0.095	0.019	0.009	0.185	0.027	0.027	0.004	0.213	0.003	0.037	0.003	0.003
35	0.086	0.022	0.006	0.257	0.027	0.017	0.003	0.297	0.002	0.027	0.002	0.002
40	0.093	0.026	0.004	0.181	0.024	0.012	0.002	0.209	0.002	0.016	0.002	0.002
45	0.108	0.032	0.003	0.109	0.027	0.009	0.002	0.126	0.002	0.013	0.001	0.001
50	0.127	0.040	0.002	0.073	0.031	0.007	0.001	0.085	0.001	0.011	0.001	0.001
55	0.152	0.044	0.002	0.053	0.036	0.006	0.001	0.061	0.001	0.009	0.001	0.001
60	0.186	0.031	0.002	0.040	0.042	0.005	0.001	0.046	0.001	0.008	0.001	0.001
65	0.207	0.022	0.001	0.032	0.050	0.004	0.001	0.036	0.001	0.007	0.001	0.001
70	0.152	0.016	0.001	0.026	0.060	0.003	0.001	0.030	0.001	0.006	0.001	0.001
75	0.112	0.013	0.001	0.021	0.052	0.003	0.001	0.024	0.001	0.006	0.001	0.001
80	0.086	0.010	0.001	0.018	0.038	0.002	0.001	0.021	0.001	0.005	0.001	0.001
85	0.069	0.008	0.001	0.015	0.030	0.002	0.001	0.018	0.001	0.005	0.000	0.000
90	0.056	0.007	0.001	0.013	0.024	0.002	0.000	0.015	0.001	0.004	0.000	0.000
95	0.047	0.006	0.001	0.012	0.019	0.002	0.000	0.013	0.000	0.004	0.000	0.000
100	0.039	0.005	0.001	0.010	0.016	0.001	0.000	0.012	0.000	0.004	0.000	0.000
Total	2.089	0.405	0.248	1.664	0.637	0.766	0.320	1.924	0.840	2.854	0.768	0.761
Remain	0.715	0.111	0.027	0.310	0.257	0.085	0.027	0.369	0.046	0.239	0.040	0.041
% Remain of Total	34	27	11	18.6	40	11	8	19	5	8	5	5

From Row and Phelps, "Determining the Flows and Disposition of Carbon in Timber Harvest and Wood-in-use," August 5-11, 1990, Montreal, Canada

Carbon Remaining in Selected Wood-in-use Sinks



From Row and Phelps, August 5-11, 1990, 19th World Congress IUFRO, Montreal, Canada